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Depressive symptoms and carotid artery intima-media thickness in police officers

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Abstract

Purpose—Police work is a stressful occupation. Depressive symptoms, which may occur as a result of exposure to stressors in police work, have been known to be associated with an increased risk of cardiovascular disease. This cross-sectional study investigated the association between depressive symptoms and carotid artery intima-media thickness (CIMT) among police officers.

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Conflict of interest The authors declare that they have no conflict of interest.

Methods—CIMT was measured with B-mode carotid ultrasonography. Depressive symptoms were measured using the Center for Epidemiological Studies Depression (CES-D) scale. Analyses of variance and covariance were utilized to examine the mean values of common CIMT (CCA IMT) and maximum CIMT (MMXIMT) across quintiles of depressive symptoms.

Results—Participants included 412 officers (mean age = 41 years). Hypertension status significantly modified the association between CES-D score and CIMT. The association between CES-D score and CCA IMT was statistically significant (adjusted $P = 0.030$) but only among officers without hypertension. The associations between CES-D score and MMXIMT were not significant among officers with or without hypertension. Our results also showed that among officers who reported poor sleep quality, mean levels of CCA IMT, and MMXIMT tended to increase as depressive symptoms increased.

Conclusions—Depressive symptoms may be therefore be independently associated with CIMT, yet masked by hypertension. Even though sleep quality did not significantly modify the main association, our results also suggest that poor sleep quality may act synergistically with depressive symptoms to increase CIMT. Future prospective work would help to clarify these associations.

Keywords

Cardiovascular disease; Depression; Risk factors; Police

Introduction

Police work is considered a stressful occupation which not only involves danger and traumatic event exposure, but also organizational stressors such as lack of support, punishment-centered executive philosophies, and excessive paperwork (Violanti et al. 2006; Berg et al. 2005; Kop and Euwema 2001; Patterson 2003; Spielberger et al. 1982; Violanti and Aron 1994).

Depression may be one outcome of exposure to police work stressors and it has been associated with increased risk of cardiovascular disease (CVD) (Wang et al. 2010; Chen et al. 2006; Whipple et al. 2011). Barefoot and Schroll (1996) found that a high level of depressive symptoms predicted the subsequent occurrence of myocardial infarction and mortality in a 21-year follow-up study. Appels and Mulder (1988) found relationships between various negative psychological states and the occurrence of coronary heart disease (CHD). Depression has also been associated with biological outcomes which exacerbate the risk of CVD, including hyperactivity within the hypothalamic–pituitary–adrenal (HPA) axis, diminished heart rate variability, and ventricular instability (Musselman et al. 1998a, b).

Due to their occupational exposure and increased risk for depression, police officers may also be at higher risk for CVD (Violanti et al. 1998; Franke and Anderson 1994; Franke et al. 1998). Based on the previous research, we tested the hypothesis that depressive symptoms in police officers are associated with carotid artery intima-media thickness (CIMT) after adjustment for traditional CVD risk factors. Stewart et al. (2007) found that higher depressive symptoms at baseline were associated with greater 3-year change in carotid intima-media thickness even after taking into account demographic factors,

cardiovascular risk factors, medication use, medical conditions, and other correlated negative emotions. Pizzi et al. (2010) found that IMT is higher in depressed subjects, indicating that atherosclerosis is accelerated in depressed patients. These authors contribute this to mechanisms which connect depression and coronary artery disease, such as inflammation and imbalance of the autonomic nervous system. Haas et al. (2005), adjusting for baseline cardiovascular risk factors, found participants with elevated depression scores at baseline were > 2 times as likely as those with no depressive symptoms to have carotid plaque. This study suggested that hypothalamic–pituitary–adrenal (HPA) dysregulation, diminished heart rate variability, altered blood platelet function, and noncompliance with medical treatments underlie the association between depression and cardiovascular disease. Conversely, Rice et al. (2009) in the Baltimore Longitudinal Study of Aging found no significant relationship between the trajectory of depressive symptoms and future carotid IMT.

CIMT progression rates have been associated with risk factors such as diabetes, smoking, hypercholesterolemia, and hypertension (Chambless et al. 2002; Ferrieres et al. 1999). CIMT has been used successfully to study arterial atherosclerotic disease in predicting cardiovascular disease outcomes (myocardial infarction, stroke), clinical coronary outcomes, determining the effectiveness of risk factor intervention, and in monitoring the progression of arterial wall thickness over time (Bots et al. 2003; Chambless et al. 1997; Grobbee and Bots 1994) In a meta-analysis of population-based CIMT studies, Lorenz et al. (2007) estimated the relative risk of myocardial infarction and stroke as 1.15 and 1.18, respectively (adjusted for age and gender), for each 0.10-mm thickness increase in common carotid IMT.

Methods

Study design and participants

Between June 2004 and October 2009, 464 police officers (active-duty and retired) among all officers in the Buffalo New York Police Department (estimated to be approximately 710 in 2004) were examined in the Buffalo Cardio-metabolic Occupational Police Stress (BCOPS) study. Women officers who were pregnant at the time of examination were excluded. Police officers perform a variety of duties. A typical routine day in this sample of officers may involve riding on patrol, walking a beat, answering complaint calls for police service, handling traffic accidents, investigating crimes, and writing reports. During routine patrol, officers may also be exposed to incidents considered to be traumatic, such as shootings, assaults, robberies, and homicides. Officers are required to work 10 h fixed shifts, including midnight shifts.

The data were collected at the Center for Health Research, School of Public Health and Health Professions, University at Buffalo, State University of New York. To be eligible for this current study, officers must have had no prior history of heart attack, stroke, bypass surgery, carotid artery endarterectomy, transient ischemic attack, or any physician-diagnosed coronary heart disease. The final sample included 412 officers with complete data (305 men and 107 women) who were currently employed, had complete information for CIMT, and had completed the Center for Epidemiologic Studies Depression (CES-D) Scale (Radloff 1977). Prior to any clinic examinations, the officers reviewed and signed informed

consent forms. The Institutional Review Board at the University at Buffalo and the National Institute for Occupational Safety and Health (NIOSH) approved the study.

Measures

Assessment of carotid intima-media thickness—Certified sonographers used a standardized ultrasound protocol that was adopted from the Center for Medical Ultrasound at Wake Forest University. High-resolution B-mode carotid ultrasonography was performed using a 7.5- to 10-MHz transducer and a Biosound Esaote (AU5) ultrasound machine (Howard et al. 1993) Prior to the measurement of CIMT, the participants lay supine in a darkened, quiet room. A cool gel was applied to the area to be scanned and a preliminary exploratory transverse scan was performed to assess the participant's anatomy and to determine the optimum angle for the CIMT scan. Standing at the head of the examination table, the sonographers scanned both the right and left extra-cranial carotid arteries. Starting at the optimal angle, standardized longitudinal images were acquired of the near and far walls of the distal 1.0 cm portion of the common carotid artery (CCA), the carotid bifurcation and proximal 1.0 cm at the optimum angle, and two additional scanning angles (30–45° anterior and 30–45° posterior). Mean common carotid artery (CCA) IMT (mm) is defined as the average of the CCA IMT measured at 12 sites in the right and left CCA. Mean maximum (MMXIMT) IMT (mm) is the average of the maximum IMT measured in the CCA, bifurcation, and internal carotid artery on both the right and left sides of the neck from three interrogation angles on the right and left side of the near and far walls (3 sites × 3 angles × 2 sides × 2 walls = 36) and was computed as the average IMT for all 36 image segments (Riley 2002). The scans were recorded on a ¾-inch (1.9 cm) high-resolution (Super VHS) video cassette and later digitized using ImagePro Plus software for measurement.

Established guidelines were used for ongoing quality control. The acceptable differences between any two ultrasound readers should not exceed <0.03 mm for the MMCCA and <0.05 mm for the MMXIMT. A phantom scan, using a tissue equivalent phantom, was performed every 2 weeks to ensure accurate calibration of the ultrasound machine and transducers.

Assessment of depressive symptoms—Depressive symptoms were measured using the Center for Epidemiological Studies Depression (CES-D) scale. The CES-D is a short scale that was designed to measure the symptoms of depression in the general population (Radloff 1977). Several dimensions of depression are measured including affective components of depression, psychomotor retardation, loss of appetite, and sleep disorder. The CES-D consists of 20 items with responses on a 4-point scale which represents the degree to which each symptom occurred during the past 7 days: 0 (rarely or none of the time, less than 1 day); 1 (some or little of the time, 1–2 days); 2 (occasionally or a moderate amount of time, 3–4 days); and 3 (most or all of the time, 5–7 days). These items are used to obtain an overall score (range = 0–60) of depressive symptoms. For analysis, the CES-D scores were categorized into quintiles: 1st quintile (0–<3), 2nd quintile (3–<5), 3rd quintile (5–<8), 4th quintile (8–<12), and 5th quintile (12–42) and also into two categories <16 (not depressed) and ≥16 (depressed).

Depressive symptoms are determined here by means of a valid and reliable questionnaire, but should not be construed at clinical depression. Clinical depression must either have a depressed mood or a loss of interest or pleasure in daily activities consistently for at least a 2-week period (American Psychiatric Association 2000 DSM-IV 1994). Our study was cross-sectional, and therefore, it was not possible to diagnose clinical depression in our sample.

Assessment of covariates—CVD risk components were based on cut-points established by the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III), the American Heart Association and the National Heart, Lung, and Blood Institute, National Institutes of Health which included abdominal obesity (gender-specific waist circumference), impaired fasting blood glucose, elevated triglycerides, elevated blood pressure, and reduced gender-specific HDL cholesterol. Hypertension was defined as taking any medication for high blood pressure or having a systolic blood pressure of ≥140 mm Hg or a diastolic blood pressure of ≥90 mm Hg. The average of the second and third of three resting systolic and diastolic blood pressure readings was used. Diabetes was defined as taking any medication for diabetes or having a fasting serum glucose level of ≥126 mg/dL (Grundy et al. 2005). Participants were weighed, and height was measured without shoes. Body mass index (BMI) was calculated as weight (in kilograms) divided by height (in meters) squared. Waist circumference was measured at the midpoint between the lowest part of the costal margin in the mid-axillary line and highest point of the iliac crest. The average value of two measurements rounded to the nearest 0.5 cm was used in the analyses. If the two measurements had a difference of more than 0.5 cm, a third measurement was performed. Blood was collected from officers who had fasted for at least 12 h the previous night. Blood parameters were measured at Kaleida Laboratory, Buffalo, NY, by standard laboratory techniques on the Beckman Coulter LX20 clinical chemistry analyzer and included a blood lipid panel for HDL and triglycerides, and chemistry panels for glucose.

Officers were given self and interviewer-administered questionnaires to provide information on demographic characteristics, lifestyle behaviors, and medical history. For educational status, they checked one of eight choices from “less than 12 years of school” to “graduate degree;” these eight categories were later collapsed into three levels (<high school/GED, college <4 years, and college 4+ years). Officers were asked how often they consumed alcoholic beverages with one drink defined as a 12-oz. can or bottle of beer, one medium glass of wine (6 oz. or 170 gm), or one shot (1 oz. or 28.4 gm) of liquor. The total number of drinks per month (of each type) was summed and then divided by 4 to give the approximate total number of drinks consumed per week. Officers reported their smoking status as current, former, or never. Hours of sleep was assessed from questionnaire data. The average hours of sleep reported for the five previous weekdays were multiplied by five and the hours reported for the weekend days were multiplied by two. The hours were then summed and divided by seven to give the total hours of sleep per 24-h period during the previous 7 days.

Sleep quality was obtained from 19 self-rated individual questions that assessed various sleep quality-related factors over the previous 1-month period. These 19 items were grouped into seven components. Each component was scored by summing the scores of each item. Each item was weighted equally on a 0–3 scale. A global PSQI score was derived by

summing up the seven component scores with a possible range of 0–21; a global score of >5 defined poor sleep quality (Buysse et al. 1989). The PSQI global score allows direct comparisons among groups, identifies groups that differ in the quality of sleep, and provides a single overall assessment of sleep quality. Studies have shown that the PSQI has high internal homogeneity, reliability, and validity (Buysse et al. 1989; Knutson et al. 2006).

Physical activity during the previous 7 days was obtained with the Seven-Day Physical Activity Recall questionnaire (Sallis et al. 1986). For three types of physical activity (occupational, household, and sports), participants reported the duration (hours per weekday, hours per weekend) and intensity (moderate, hard, very hard). A total physical activity score was then computed by summing the intensities of the three types of physical activity performed during the weekday and weekend, and multiplying that number by the reported duration.

Statistical analysis

Simple descriptive measures were calculated for all variables. Associations for all covariates with CES-D scores and CIMT were examined using the chi-square test of independence and analysis of variance (ANOVA). ANOVA and analysis of covariance (ANCOVA) were utilized to examine the mean values of CCA IMT and MMXIMT across quintiles of depressive symptoms. Depressive symptoms were categorized into quintiles in order to present mean values of the dependent variables which facilitate the interpretation of the results. The *p* values for linear trends were obtained from linear regression models utilizing the continuous forms of both dependent and independent variables. Effect modification was assessed for antidepressant medication use, BMI, smoking status, alcohol consumption status, physical activity status, history of hypertension and diabetes, race/ethnicity, gender, sleep duration, and sleep quality. Confounders were selected based on their associations with the main exposures and outcomes or on the scientific literature. The potential confounders were age, gender, race/ethnicity, educational level, cigarette smoking status, alcohol intake, waist circumference, HDL cholesterol, LDL cholesterol, triglycerides, glucose, diabetes, systolic blood pressure, hypertension, antidepressant medication use, and physical activity. All analyses were conducted in SAS version 9.2 2008 (SAS; Cary, NC).

Results

The mean age (±SD) of all officers (n = 412) was 41.0 ± 7.1 years (Table 1). The age ranges for men and women were 21–66 and 26–53 years, respectively. The majority of officers were Caucasian (76.8 %), 16.7 % were current smokers, and 19.9 % reported 8 drinks or more per week. Approximately 24 % of all officers had a history of hypertension and 2.7 % a history of diabetes. Women had slightly higher CES-D scores than men (8.7 ± 8.2 vs. 7.4 ± 6.6). In contrast, men had slightly higher mean CCA IMT (0.626 mm vs. 0.587 mm) and MMXIMT (0.801 mm vs. 0.729 mm) values than women.

Results for the association between demographic, lifestyle characteristics, and CES-D scores are presented in Table 2. Low-density lipoprotein (LDL) cholesterol and triglycerides generally increased with increasing quintiles of CES-D scores but the associations were not statistically significant. Race/ethnicity was associated with CES-D scores, P = 0.029. Use of

antidepressant medications was also associated with CES-D scores, $P = 0.004$. Table 3 provides associations between selected demographics, traditional CVD risk factors, CCA IMT, and MMXIMT. Most results were in the expected direction. LDL cholesterol, glucose levels, diabetes, and hypertension were positively and significantly correlated with both CIMT measures, whereas high-density lipoprotein (HDL) was inversely and significantly associated with both. Mean levels of CCA IMT and MMXIMT differed significantly by race/ethnicity, with Caucasians having the lowest mean levels and Hispanic-American officers having the highest mean levels of both CCA IMT ($P = 0.007$) and MMXIMT ($P = 0.007$).

After adjustment for age, gender, race, education level, cigarette smoking status, alcohol intake, body mass index (BMI), HDL cholesterol, LDL cholesterol, triglycerides, glucose, and hypertension, officers with CES-D scores >16 had a higher mean CCA IMT value (0.628 ± 0.013) than officers with lower CES-D scores, but the difference was not statistically significant ($P = 0.130$) (data not shown). Similar results were observed with MMXIMT. The results in Table 4 show no significant association for CES-D scores with CCA IMT or MMXIMT, before or after adjustment for covariates.

To help clarify associations between depressive symptoms, CVD risk factors, and CIMT, we stratified by traditional CVD risk factors based on the cut-points recommended by the National Cholesterol Education Program Adult Treatment Panel III (NCEP ATP III), the American Heart Association and the National Heart, Lung, and Blood Institute, National Institutes of Health. With the exception of hypertension (SPB ≥ 140 mm Hg; DBP ≥ 90 mm Hg or medication use), no significant associations were observed between depressive symptoms and CIMT after stratification.

Hypertension status significantly modified the association between CES-D and CCA IMT (interaction $P = 0.088$) and between CES-D and MMXIMT (interaction $P = 0.083$). Table 5 displays mean values of CCA IMT and MMXIMT across quintiles of CES-D score, stratified by hypertension status. Among officers without hypertension, depressive symptoms were positively and significantly associated with CCA IMT in the unadjusted model ($P = 0.041$). This association remained statistically significant after inclusion of several confounders and CVD risk factors ($P = 0.030$). The associations between CES-D and MMXIMT were not statistically significant among the officers with or without hypertension.

Although sleep quality did not significantly modify the association between CES-D and CIMT, the associations among officers who reported poor sleep quality versus those who reported good sleep quality were substantially different (though not statistically significant) to warrant mention in this paper. Among officers who reported poor sleep quality, mean values of both CCA IMT and MMXIMT increased as depressive symptoms (CES-D scores) increased; adjusted p values for linear trends were =0.071 and 0.083, respectively. Among officers who reported good sleep quality, the associations of depressive symptoms with CCA IMT and MMXIMT did not show a similar positive relationship nor were they statistically significant.

Discussion

The goal of this study was to investigate the cross-sectional association of depressive symptoms with subclinical cardiovascular markers CIMT and MMXIMT among police officers. As expected, traditional risk factors remained strong predictors of CIMT. Age, BMI, LDL cholesterol, and glucose levels were positively and significantly correlated with CIMT measures, whereas high-density lipoprotein (HDL) was inversely and significantly associated with both. We stratified by traditional CVD risk factors to reveal whether any of these risk factors might modify the association between depressive symptoms and CIMT. No significant differences were noted in the associations between depressive symptoms and CIMT after stratification with one exception: hypertension. A significant positive association between depressive symptoms and CIMT was observed in officers who were free of hypertension. Additionally, hypertension significantly modified the association between CES-D and CCAIMT. This result indicated that depressive symptoms may be independently associated with CIMT, yet only among participants free of hypertension. Recent work on depression and hypertension has provided evidence of increased sympathetic activity and increased blood pressure reactivity (Jonas and Lando 2000; Jonas et al. 1997; Bowman and Nicklin 1997; Veith et al. 1994; Waked and Jutai 1990). These studies suggest that depression may have an effect on the cardiovascular system that could lead to the development of hypertension and possible future CVD. Our results also showed that among officers who reported poor sleep quality (Table 6), mean levels of CIMT tended to increase as depressive symptoms increased. Even though sleep quality did not significantly modify the main association, our results suggest that poor sleep quality may act synergistically with depressive symptoms to increase CIMT. Violanti et al. (2009) found that police officers working midnight shifts combined with either shorter sleep duration or increased overtime may be at an increased risk for metabolic syndrome. The prevalence of metabolic syndrome among officers working the midnight shift was higher than that found in the National Health and Nutrition Examination Survey (NHANES III) 1988–1994 (Ford et al. 2002). Karlsson et al. (2001) found that obesity, high triglycerides, and low concentrations of HDL cholesterol seem to cluster together more often in shift workers than in day workers. Lasfargues et al. (1996) found night-shift workers have significantly higher levels of triglycerides, smoking, and obesity than controls. In a review of the literature, Wolk and Somers (2007) found that the weight of evidence suggested that sleep deprivation and shift work independently lead to the development of both insulin resistance and individual components of the metabolic syndrome. Other studies found the metabolic effects of shift work to include abdominal obesity, lower HDL cholesterol and higher triglycerides, and changes in glucose intolerance (Nagaya et al. 2002). Mean levels of CCA IMT and MMXIMT differed significantly by race/ethnicity, with Caucasians having the lowest mean levels and Hispanic-American officers having the highest mean levels of both CCA IMT ($P = 0.007$) and MMXIMT ($P = 0.007$). The small number of Hispanic Americans in our study prevented any meaningful conclusions concerning CIMT and depressive symptoms. African Americans had significantly greater mean CIMT than did Caucasians in our cohort; however, no significant interactions with depressive symptoms were found. This was not surprising, as African Americans are more likely to have a higher prevalence of CVD than whites and are also 1.5 times as likely as whites to have hypertension and 10 % less likely

than whites to have their blood pressure under control (http://www.cdc.gov/nchs/data/series/sr_10/sr10_249.pdf).

In a recent study, higher levels of hopelessness (a diagnostic criterion of depression) were associated with increased CIMT (Whipple et al. 2011). The authors stated that hopelessness confers an independent risk of CVD. For minority officers, there may be social conditions or exposures within police work that increase the risk of both depressive symptoms and hopelessness.

Behaviors related to stress or depression may also increase the risk for CVD in officers. The low physical fitness level found among police officers may be an indicator. Williams (1987) found that a substantial number of officers in their sample were at elevated risk for atherosclerotic heart disease: 76 % had elevated cholesterol, 26 % had elevated triglycerides, and 60 % elevated body fat composition. Price et al. (1978) concluded that middle-aged police officers had CVD risk above that of the general population. Joseph et al. (2009) found that police officers have increased levels of atherosclerosis compared with a general population sample, which was not fully explained by elevated CVD risk factors, thereby potentially implicating other mechanisms whereby law enforcement work may increase CVD risk. Franke and Anderson (1994) found that public safety officers had a higher probability of developing CHD than did the Framingham Heart Study population. Steinhardt et al. (1991) found an inverse association between cardiovascular fitness and medical claims among police officers. Of interest is the fact that police officers either suffer from disease or die at a much earlier age than do reference groups such as municipal workers or the general US population (Violanti et al. 1998; Franke et al. 1998). Officers also died from CVD at earlier ages than the general population (Violanti et al. 1998). This suggests the possible influence of lifestyle risk factors for those diseases, including psychological stress and depression.

This study is cross-sectional and cannot determine the causal direction between depressive symptoms and CIMT. Future prospective investigations may help to clarify this issue. Other limitations of this study are the lack of complete recruitment of all members of the police force, residual confounding, and the possibility of selection bias. To clarify whether officers who were examined were representative of all officers, we compared those officers who participated versus those who did not; summary characteristics were as follows: 26 versus 23 % women; 30 versus 28 % above 45 years of age; 66 versus 71 % police officers (vs. higher rank); and 45 versus 39 % hired after 1990, respectively. The results suggest that findings are likely to be generalizable to the entire Buffalo Police Department. The potential for residual confounding in this analysis could remain due to incomplete adjustment, and there could be other unmeasured variables that could not be adjusted for in the analysis. Another limitation of the study is the limited period of time for which information on depressive symptoms is available (i.e., 7 days). Data on the history of depressive symptoms or depressive disorders were not available for this cohort. If the association was causal, it might take years of exposure to depressive symptoms before an adverse effect on carotid IMT would be evident.

This study has the advantage of being conducted in a controlled clinical setting, where the assessment of many CVD risk factors (such as blood pressure or cholesterol) is conducted by trained clinic personnel. Data collection for all studies was performed at the same site, using a standardized protocol during similar time frames by the same research team. As suggested by Joseph et al. (2009), subclinical CIMT is a predictive measure of future CVD disease. The use of subclinical markers prior to CVD event manifestation is beneficial, in that preventive efforts may be initiated well in advance of clinically apparent disease.

In sum, the present study suggests that, other than when stratified by hypertension, no significant associations were observed for depressive symptoms with CCA IMT and MMXIMT, after adjustment for demographics and traditional CVD risk factors. However, among officers without hypertension, mean levels of CCA IMT increased with increasing quintiles of CES-D scores. This association was statistically significant after adjustment for several confounders and CVD risk factors (BMI, HDL cholesterol, LDL cholesterol, triglycerides, and serum glucose levels). This result may reflect difficulty detecting an association of depressive symptoms with CIMT in individuals with hypertension due to the strong influence of hypertension on CIMT, whereas such an association may be easier to detect in those free of hypertension. If confirmed in other studies and in a prospective design, efforts to reduce depressive symptoms and to prevent its occurrence might prevent increased CIMT. There are some studies which do provide directional evidence that depressive symptoms may have an adverse effect on the cardiovascular system that could lead to the development of hypertension and CVD (Waked and Jutai 1990; Julius 1988). Future prospective work is planned with the present police cohort to help clarify such possible directional relationships between depressive symptoms and CVD. It will also be necessary to examine not only depressive symptoms, but other variables associated with police work such as hopelessness and behavioral lifestyles that may further exacerbate earlier signs of cardiovascular disease.

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Table 1

Demographic and lifestyle characteristics by gender, BCOPS study

Characteristics	Men (*n* = 305)		Women (*n* = 107)		Total (*n* = 412)	
	N	Mean (SD)	*N*	Mean (SD)	*N*	Mean (SD)
Age (years)	305	41.1 (7.4)	107	40.7 (6.1)	412	41.0 (7.1)
BMI (kg/m^2)	303	30.3 (4.2)	107	26.0 (4.7)	410	29.2 (4.7)
Waist circumference (cm)	305	99.1 (11.3)	107	80.0 (11.6)	412	94.2 (14.1)
Police service (years)	302	14.9 (7.7)	107	13.5 (6.8)	409	14.6 (7.5)
Hours of sleep/day	300	6.3 (1.2)	106	6.4 (1.3)	406	6.3 (1.2)
Sleep quality (global score)	278	6.3 (3.2)	104	7.0 (3.7)	382	6.5 (3.3)
HDL cholesterol (mg/dL)	304	42.2 (12.0)	105	58.3 (15.8)	409	46.3 (14.8)
LDL cholesterol (mg/dL)	303	131.0 (33.5)	104	118.9 (31.7)	407	128.0 (33.4)
Triglycerides (mg/dL)	304	153.5 (127.5)	105	88.5 (130.6)	409	136.8 (131.3)
Glucose (mg/dL)	304	94.6 (13.9)	106	86.3 (8.3)	410	92.5 (13.2)
C-reactive protein (mg/L)	304	3.23 (6.39)	105	2.74 (3.26)	409	3.10 (5.75)
Physical activity score	303	21.0 (18.3)	107	21.8 (17.6)	410	21.3 (18.1)
Systolic blood pressure (mmHg)	305	122.3 (11.3)	107	116.5 (13.3)	412	120.8 (12.1)
Depressive symptoms (CES-D score)	305	7.4 (6.6)	107	8.7 (8.2)	412	7.8 (7.0)
CCA IMT (mm)	305	0.626 (0.105)	107	0.587 (0.078)	412	0.616 (0.100)
MMXIMT (mm)	305	0.801 (0.150)	107	0.729 (0.102)	412	0.782 (0.143)
Ethnicity		%		%		%
European American	237	78.2	78	72.9	315	76.8
African American	53	17.5	29	27.1	82	20.0
Hispanic American	13	4.3	0	0	13	3.2
Education						
<=High school/GED	38	12.6	4	3.7	42	10.2
College <4 years	160	53.0	66	61.7	226	55.3
College 4+ years	104	34.4	37	34.6	141	34.5
Marital status						
Single	28	9.3	23	21.5	51	12.5

Characteristics	Men (*n* = 305)		Women (*n* = 107)		Total (*n* = 412)	
	N	Mean (SD)	*N*	Mean (SD)	*N*	Mean (SD)
Married/unmarried couple	236	78.4	63	58.9	299	73.3
Divorced/separated	37	12.3	21	19.6	58	14.2
Cigarette smoking status						
Never	199	65.7	46	43.8	245	60.0
Former	64	21.1	31	29.5	95	23.3
Current	40	13.2	28	26.7	68	16.7
Alcohol intake (drinks/week)						
None	51	16.7	26	24.3	77	18.7
<1	46	15.1	23	21.5	69	16.7
1–3	71	23.3	22	20.6	93	22.6
4–7	69	22.6	22	20.6	91	22.1
8+	68	22.3	14	13.1	82	19.9
Sleep quality						
Good	130	42.6	46	43.0	176	42.7
Poor	148	48.5	58	54.2	206	50.0
Antidepressant medication use	19	6.3	12	11.2	31	7.6
Hypertension	80	26.2	18	16.8	98	23.8
Diabetes	10	3.3	1	0.9	11	2.7

Hypertension was defined as taking any medication for high blood pressure or SBP ≥ 140 or DBP ≥ 90

Diabetes was defined as taking any medication for diabetes or fasting serum glucose ≥126

BMI body mass index, *BP* blood pressure, *CIMT* carotid intima-media thickness, *CES-D* center for epidemiologic studies depression scale

Table 2

Selected characteristics by quintiles of CES-D score, BCOPS study

	Quintiles of CES-D score					*P*
	0–2.9 (*n* = 88)	**3–4.9 (*n* = 74)**	**5–7.9 (*n* = 80)**	**8–11.9 (*n* = 80)**	**12–42 (*n* = 90)**	
Age (years)	40.5 ± 8.1	40.8 ± 6.3	41.4 ± 7.5	41.3 ± 6.6	40.8 ± 7.0	0.833
BMI (kg/m^2)	28.8 ± 3.4	29.8 ± 4.9	28.7 ± 4.8	29.8 ± 5.6	28.8 ± 4.6	0.487
Waist circumference (cm)	93.3 ± 12.2	94.6 ± 14.4	92.8 ± 14.0	96.6 ± 15.9	93.7 ± 14.2	0.827
Police service (years)	14.0 ± 8.0	14.2 ± 6.4	15.9 ± 8.1	14.3 ± 7.7	14.4 ± 6.9	0.999
Hours of sleep per 24-h period	6.4 ± 1.3	6.1 ± 1.2	6.4 ± 1.2	6.4 ± 1.2	6.3 ± 1.2	0.726
Sleep quality	5.0 ± 2.8	5.4 ± 2.6	5.5 ± 3.4	7.4 ± 3.0	8.9 ± 3.0	<0.0001
HDL cholesterol (mg/dL)	47.0 ± 14.8	43.3 ± 13.8	46.7 ± 13.9	47.8 ± 16.2	46.6 ± 15.1	0.702
LDL cholesterol (mg/dL)	125.8 ± 31.1	126.4 ± 30.9	124.0 ± 28.9	127.1 ± 35.5	135.5 ± 38.7	0.160
Triglycerides (mg/dL)	126.2 ± 106.6	140.5 ± 151.7	112.9 ± 80.3	136.6 ± 103.5	165.7 ± 181.1	0.087
Glucose (mg/dL)	92.1 ± 10.9	92.5 ± 9.6	92.4 ± 12.6	91.5 ± 10.3	93.7 ± 19.5	0.753
C-reactive protein (mg/L)	2.8 ± 3.3	2.2 ± 1.9	3.7 ± 8.8	4.2 ± 8.1	2.6 ± 3.0	0.959
Physical activity score	20.7 ± 17.2	21.6 ± 15.8	19.8 ± 16.6	21.1 ± 17.0	22.9 ± 22.6	0.784
Systolic blood pressure (mmHg)	120.2 ± 12.0	121.6 ± 11.0	121.0 ± 13.7	121.0 ± 11.3	120.4 ± 12.5	0.721
Race/ethnicity (%)						
Caucasian	83.0	63.0	77.5	74.7	83.3	0.029
African American	17.0	31.5	21.3	20.3	12.2	
Hispanic American	0	5.5	1.3	5.0	4.4	
Education (%)						
≤High school/GED	10.2	12.3	8.8	8.9	11.2	0.937
College <4 years	60.2	52.1	51.3	55.7	56.2	
College ≥4 years	29.6	35.6	40.0	35.4	32.6	
Marital status (%)						
Single	10.2	15.3	8.8	13.9	14.6	0.909
Married/unmarried	76.1	72.2	77.5	72.2		
Divorced/separated	13.6	12.5	13.8	13.9	16.9	
Smoking status (%)						
Never	58.6	61.6	65.0	54.4	60.0	0.768

	Quintiles of CES-D score					*P*
	0–2.9 (*n* = 88)	**3–4.9 (*n* = 74)**	**5–7.9 (*n* = 80)**	**8–11.9 (*n* = 80)**	**12–42 (*n* = 90)**	
Former	26.4	24.7	21.3	24.1	20.0	
Current	15.0	13.7	12.5	21.5	20.0	
Alcohol intake (drinks/wk)						
None	20.5	24.3	17.5	15.0	16.7	
<1	13.6	24.3	20.0	11.3	15.6	
1–3	30.7	14.9	28.8	18.8	18.9	
4–7	21.6	18.9	15.0	28.8	25.6	
≥8	13.6	17.6	18.8	26.3	23.3	0.126
Sleep quality						
Good	63.9	58.8	60.3	32.9	17.7	<0.0001
Poor	36.1	41.2	39.7	67.1	82.3	
Antidepressant medication	5.7	5.5	5.0	2.5	17.8	0.004
Hypertension (%)	25.0	24.3	26.3	21.3	22.2	0.944
Diabetes (%)	2.3	4.1	5.0	0	2.2	0.306

Results are means ± standard deviations or percentages

The *p* values for continuous variables are from linear regression models, and for the categorical variables, chi-square

BMI body mass index, *BP* blood pressure, *HDL* high-density lipoprotein, *LDL* low-density lipoprotein

Table 3

Selected characteristics by CCA IMT and MMXIMT measures, BCOPS study

Covariates	CCA IMT	MMXIMT
Age (years)	0.5093, <0.0001	0.5425, <0.0001
BMI (kg/m^2)	0.2509, <0.0001	0.2696, <0.0001
Waist circumference (cm)	0.2634, <0.0001	0.2846, <0.0001
Police service (years)	0.3935, <0.0001	0.4349, <0.0001
Hours of sleep per 24-h period	−0.0066, 0.895	−0.0282, 0.571
Sleep quality	−0.0444, 0.387	−0.0856, 0.095
HDL cholesterol (mg/dL)	−0.1469, 0.0029	−0.1516, 0.0021
LDL cholesterol (mg/dL)	0.1327, 0.0074	0.1360, 0.0060
Triglycerides (mg/dL)	0.0987, 0.0460	0.0633, 0.2014
Glucose (mg/dL)	0.1661, 0.0007	0.2012, <0.0001
C-reactive protein (mg/L)	0.0839, 0.0901	0.0598, 0.2277
Physical activity score	0.0756, 0.126	0.0751, 0.129
Systolic blood pressure (mmHg)	0.2295, <0.0001	0.2155, <0.0001
Race/ethnicity		
European American	0.608 ± 0.100	0.773 ± 0.139
African American	0.640 ± 0.095	0.801 ± 0.115
Hispanic American	0.665 ± 0.106	0.889 ± 0.285
p value*	0.007	0.007
Education		
<=High school/GED	0.627 ± 0.090	0.813 ± 0.137
College <4 years	0.621 ± 0.110	0.780 ± 0.155
College 4+ years	0.604 ± 0.086	0.777 ± 0.123
p value†	0.202	0.153
Marital status		
Single	0.595 ± 0.097	0.742 ± 0.116
Married/unmarried couple	0.613 ± 0.095	0.785 ± 0.151
Divorced/separated	0.646 ± 0.124	0.802 ± 0.116
p value*	0.020	0.071
Cigarette smoking status		
Never	0.607 ± 0.093	0.772 ± 0.114
Former	0.638 ± 0.117	0.813 ± 0.188
Current	0.619 ± 0.100	0.773 ± 0.160
p value*	0.037	0.055
Alcohol intake (drinks/week)		
None	0.543 ± 0.078	0.676 ± 0.154
<1	0.603 ± 0.082	0.777 ± 0.136
1–3	0.630 ± 0.105	0.789 ± 0.139
4–7	0.608 ± 0.089	0.770 ± 0.129

Covariates	CCA IMT	MMXIMT
8+	0.619 ± 0.120	0.791 ± 0.175
p value††	0.441	0.283
Sleep quality		
Good	0.626 ± 0.008	0.803 ± 0.011
Poor	0.607 ± 0.007	0.763 ± 0.010
p value*	0.069	0.008
Antidepressant medication use		
Yes	0.616 ± 0.105	0.890 ± 0.169
No	0.616 ± 0.100	0.890 ± 0.217
p value*	0.977	0.986
Hypertension		
Yes	0.663 ± 0.123	0.843 ± 0.192
No	0.602 ± 0.088	0.764 ± 0.119
p value*	<0.0001	<0.0001
Diabetes		
Yes	0.687 ± 0.100	0.979 ± 0.364
No	0.614 ± 0.100	0.777 ± 0.128
p value*	0.016	<0.0001

Results are Pearson's correlation coefficients and mean ± SD

*p value for any difference between the means

†p value from polynomial orthogonal contrast linear trend

††p value from linear regression models

Table 4

Unadjusted and adjusted mean values of the CCA IMT and MMXIMT across quintiles of CES-D score, BCOPS study

	Quintiles of CES-D score					*p* value*
	0–2.9 (*n* = 88)	**3–4.9 (*n* = 74)**	**5–7.9 (*n* = 80)**	**8–11.9 (*n* = 80)**	**12–42 (*n* = 90)**	
CCA IMT (mm)						
Model 1	0.617 ± 0.114	0.607 ± 0.089	0.612 ± 0.101	0.616 ± 0.093	0.624 ± 0.102	0.479
Model 2	0.621 ± 0.013	0.600 ± 0.013	0.612 ± 0.013	0.612 ± 0.013	0.630 ± 0.013	0.300
Model 3	0.652 ± 0.021	0.629 ± 0.020	0.646 ± 0.021	0.640 ± 0.021	0.660 ± 0.020	0.356
MMXIMT (mm)						
Model 1	0.785 ± 0.147	0.784 ± 0.172	0.784 ± 0.142	0.777 ± 0.120	0.781 ± 0.133	0.735
Model 2	0.805 ± 0.018	0.788 ± 0.018	0.795 ± 0.019	0.779 ± 0.018	0.800 ± 0.017	0.663
Model 3	0.887 ± 0.028	0.867 ± 0.028	0.878 ± 0.028	0.861 ± 0.029	0.884 ± 0.028	0.763

Values are means (standard deviations) for unadjusted models or means (standard errors) for adjusted models

Model 1: Unadjusted

Model 2: Adjusted for age, gender, race, educational level, cigarette smoking status, and alcohol intake

Model 3: Adjusted for age, gender, race, educational level, cigarette smoking status, alcohol intake, waist circumference, HDL cholesterol, LDL cholesterol, triglycerides, glucose, diabetes, systolic blood pressure, hypertension, antidepressant medication use, and physical activity

CCA IMT common carotid intima-media thickness, *MMXIMT* maximum carotid intima-media thickness, *CES-D* center for epidemiologic studies depression scale

* *p* values are from linear orthogonal contrasts

Table 5

Unadjusted and adjusted mean values of the CCA IMT and MMXIMT across quintiles of CES-D score, stratified by hypertension, BCOPS study

	Quintiles of CES-D score					*p* value*
	0–2.9 (*n* = 88)	**3–4.9 (*n* = 74)**	**5–7.9 (*n* = 80)**	**8–11.9 (*n* = 80)**	**12–42 (*n* = 90)**	
CCA IMT (mm)						
Hypertension	*n* = 19	*n* = 18	*n* = 20	*n* = 17	*n* = 19	
Model 1	0.694 ± 0.178	0.658 ± 0.115	0.667 ± 0.139	0.673 ± 0.083	0.622 ± 0.065	0.157
Model 2	0.715 ± 0.034	0.659 ± 0.034	0.663 ± 0.037	0.674 ± 0.038	0.642 ± 0.037	0.144
Model 3	0.781 ± 0.051	0.710 ± 0.049	0.747 ± 0.052	0.720 ± 0.055	0.701 ± 0.050	0.116
No hypertension	*n* = 69	*n* = 56	*n* = 60	*n* = 63	*n* = 71	
Model 1	0.596 ± 0.078	0.591 ± 0.074	0.593 ± 0.077	0.601 ± 0.090	0.625 ± 0.110	0.041
Model 2	0.590 ± 0.014	0.583 ± 0.014	0.593 ± 0.014	0.593 ± 0.013	0.622 ± 0.013	0.013
Model 3	0.610 ± 0.023	0.600 ± 0.024	0.610 ± 0.024	0.611 ± 0.024	0.637 ± 0.023	0.030
MMXIMT (mm)						
Hypertension						
Model 1	0.866 ± 0.221	0.877 ± 0.261	0.849 ± 0.207	0.864 ± 0.107	0.764 ± 0.108	0.126
Model 2	0.919 ± 0.054	0.861 ± 0.053	0.848 ± 0.058	0.867 ± 0.059	0.786 ± 0.057	0.063
Model 3	1.192 ± 0.071	1.084 ± 0.067	1.114 ± 0.072	1.140 ± 0.075	1.049 ± 0.068	0.078
No hypertension						
Model 1	0.763 ± 0.111	0.754 ± 0.120	0.762 ± 0.106	0.753 ± 0.113	0.785 ± 0.139	0.346
Model 2	0.760 ± 0.018	0.752 ± 0.019	0.764 ± 0.018	0.745 ± 0.017	0.784 ± 0.017	0.288
Model 3	0.752 ± 0.030	0.740 ± 0.030	0.750 ± 0.030	0.731 ± 0.030	0.768 ± 0.029	0.530

Interaction *p* value = 0.062

Values are means (standard deviations) for unadjusted models or means (standard errors) for adjusted models

Model 1: Unadjusted

Model 2: Adjusted for age, gender, race, educational level, cigarette smoking status, and alcohol intake

Model 3: Adjusted for age, gender, race, educational level, cigarette smoking status, alcohol intake, waist circumference, HDL cholesterol, LDL cholesterol, triglycerides, glucose, diabetes, systolic blood pressure, hypertension, antidepressant medication use, and physical activity

Interaction by hypertension status for CCA IMT: $p = 0.088$

Interaction by hypertension status for MMXIMT: $p = 0.083$

CIMT carotid intima-media thickness, *CES-D* center for epidemiologic studies depression scale

* *p* values are from linear orthogonal contrasts

Table 6

Unadjusted and adjusted mean values of the CCA IMT and MMXIMT across quintiles of CES-D score, stratified by sleep quality, BCOPS study

	Quintiles of CES-D score					*p* value*
	0–2.9 (*n* = 83)	**3–4.9 (*n* = 68)**	**5–7.9 (*n* = 73)**	**8–11.9 (*n* = 73)**	**12–42 (*n* = 85)**	
CCA IMT (mm)						
Poor sleep quality	(*n* = 30)	(*n* = 28)	(*n* = 29)	(*n* = 49)	(*n* = 70)	
Model 1	0.587 ± 0.083	0.597 ± 0.072	0.595 ± 0.093	0.614 ± 0.091	0.618 ± 0.085	0.060
Model 2	0.600 ± 0.018	0.596 ± 0.018	0.603 ± 0.018	0.607 ± 0.015	0.626 ± 0.014	0.093
Model 3	0.615 ± 0.030	0.608 ± 0.028	0.618 ± 0.028	0.619 ± 0.028	0.644 ± 0.027	0.071
Good sleep quality	(*n* = 53)	(*n* = 40)	(*n* = 44)	(*n* = 24)	(*n* = 15)	
Model 1	0.636 ± 0.129	0.618 ± 0.102	0.611 ± 0.097	0.617 ± 0.107	0.664 ± 0.165	0.467
Model 2	0.634 ± 0.021	0.602 ± 0.020	0.609 ± 0.021	0.624 ± 0.025	0.667 ± 0.029	0.159
Model 3	0.697 ± 0.039	0.661 ± 0.038	0.677 ± 0.039	0.672 ± 0.043	0.722 ± 0.044	0.331
MMXIMT (mm)						
Poor sleep quality						
Model 1	0.736 ± 0.094	0.755 ± 0.103	0.750 ± 0.112	0.777 ± 0.126	0.775 ± 0.125	0.091
Model 2	0.751 ± 0.024	0.745 ± 0.023	0.757 ± 0.023	0.762 ± 0.019	0.782 ± 0.018	0.104
Model 3	0.730 ± 0.039	0.721 ± 0.036	0.734 ± 0.037	0.738 ± 0.037	0.765 ± 0.036	0.083
Good sleep quality						
Model 1	0.815 ± 0.168	0.808 ± 0.212	0.794 ± 0.159	0.769 ± 0.119	0.826 ± 0.176	0.890
Model 2	0.839 ± 0.031	0.804 ± 0.029	0.814 ± 0.031	0.799 ± 0.036	0.844 ± 0.042	0.956
Model 3	1.095 ± 0.051	1.052 ± 0.049	1.075 ± 0.051	1.038 ± 0.056	1.074 ± 0.056	0.494

Values are means (standard deviations) for unadjusted models or means (standard errors) for adjusted models

Model 1: Unadjusted

Model 2: Adjusted for age, gender, race, educational level, cigarette smoking status, and alcohol intake

Model 3: Adjusted for age, gender, race, educational level, cigarette smoking status, alcohol intake, waist circumference, HDL cholesterol, LDL cholesterol, triglycerides, glucose, diabetes, systolic blood pressure, hypertension, antidepressant medication use, and physical activity

Interaction by sleep quality for CCA IMT: $p = 0.703$

Interaction by sleep quality for MMXIMT: $p = 0.249$

CCA IMT common carotid intima-media thickness, *MMXIMT* maximum carotid intima-media thickness, *CES-D* center for epidemiologic studies depression scale

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* *p* values are from linear orthogonal contrasts